

1    CLAIMS

2    What is claimed is:

- 3    1. An optical apparatus, comprising:  
4       a bottom surface and walls formed on a first substrate and substantially defining a  
5       detection volume and an upper opening thereof;  
6       an optical waveguide having an end face, the optical waveguide aligned  
7       substantially parallel to the first substrate and positioned so that at least a  
8       portion of light emerging from the end face enters the detection volume; and  
9       a photodetector having an active area on a detector substrate, the detector  
10      substrate mounted on the first substrate so as to cover at least a portion of the  
11      upper opening of the detection volume with at least a portion of the active area  
12      exposed to the detection volume.
- 13    2. The apparatus of Claim 1, wherein the walls are formed at least in part by a ridge  
14      protruding from the substrate.
- 15    3. The apparatus of Claim 1, wherein the walls are formed at least in part by a  
16      recessed area formed on the substrate.
- 17    4. The apparatus of Claim 1, wherein the optical waveguide is formed on the first  
18      substrate.
- 19    5. The apparatus of Claim 4, wherein the walls of the detection volume are formed at  
20      least in part from material used to form the cladding of the optical waveguide.
- 21    6. The apparatus of Claim 4, wherein the walls of the detection volume are formed at  
22      least in part by material used to form the core of the optical waveguide.
- 23    7. The apparatus of Claim 6, wherein the core material forming the core of the optical  
24      waveguide and partly forming the walls of the detection volume is non-contiguous.
- 25    8. The apparatus of Claim 1, wherein the optical waveguide is formed on a  
26      waveguide substrate, and the optical waveguide is mounted on the first substrate.

- 1    9. The apparatus of Claim 8, wherein light emerging from the end face of the optical  
2        waveguide may enter the detection volume through a passage through one of the  
3        walls thereof.
- 4    10. The apparatus of Claim 8, wherein light emerging from the end face of the optical  
5        waveguide may enter the detection volume through a substantially transparent  
6        segment of one of the walls thereof.
- 7    11. The apparatus of Claim 8, further comprising a reflective coating on an area of the  
8        first substrate where light emerging from the end face of the optical waveguide  
9        may enter the detection volume.
- 10   12. The apparatus of Claim 8, further comprising a reflective coating on the waveguide  
11        substrate at the end face of the optical waveguide.
- 12   13. The apparatus of Claim 1, further comprising substantially transparent embedding  
13        material substantially filling the detection volume, substantially covering the end  
14        face of the optical waveguide, and substantially filling an optical path between the  
15        end face of the optical waveguide and the detection volume.
- 16   14. The apparatus of Claim 13, wherein at least one wall of the detection volume has  
17        a passage therethrough for admitting liquid embedding material into the detection  
18        volume.
- 19   15. The apparatus of Claim 1, wherein the detection volume is substantially sealed by  
20        mounting of the photodetector over the upper opening of the detection volume.
- 21   16. The apparatus of Claim 15, further comprising a substantially flat substantially  
22        contiguous upper mounting surface surrounding the upper opening of the  
23        detection volume, wherein the upper mounting surface engages the photodetector  
24        to substantially seal the detection volume.
- 25   17. The apparatus of Claim 15, further comprising multiple substantially flat  
26        substantially coplanar upper mounting surfaces arranged around the upper

1 opening of the detection volume, wherein the upper mounting surfaces engage the  
2 photodetector and gaps between the upper mounting surfaces are substantially  
3 filled with at least one of adhesive and solder, thereby substantially sealing the  
4 detection volume.

5 18. The apparatus of Claim 1, further comprising a reflective coating on a least a  
6 portion of the bottom surface of the detection volume.

7 19. The apparatus of Claim 18, wherein the reflective coating comprises a metallic  
8 coating.

9 20. The apparatus of Claim 19, wherein the metallic reflective coating serves as an  
10 electrical contact for the photodetector.

11 21. The apparatus of Claim 1, wherein at least a portion of the inner face is tilted  
12 upward.

13 22. The apparatus of Claim 1, wherein at least a portion of the inner face is adapted  
14 for reducing optical feedback from the detection volume through the end face into  
15 the optical waveguide.

16 23. The apparatus of Claim 1, wherein the end face of the optical waveguide is tilted  
17 downward so that light emerging from the end face is refracted toward the  
18 photodetector.

19 24. A method, comprising:  
20 forming a bottom surface and walls on a first substrate, thereby substantially  
21 defining a detection volume and an upper opening thereof;  
22 positioning an optical waveguide substantially parallel to the first substrate so that  
23 at least a portion of light emerging from an end face of the optical waveguide  
24 enters the detection volume;  
25 mounting a detector substrate on the first substrate so as to cover at least a  
26 portion of the upper opening of the detection volume with at least a portion of  
27 an active area on the detector substrate exposed to the detection volume.

- 1    25. The method of Claim 24, wherein the walls formed at least in part by a ridge
- 2       protruding from the substrate.
- 3    26. The method of Claim 24, wherein the walls are formed at least in part by a
- 4       recessed area formed on the substrate.
- 5    27. The method of Claim 24, further comprising forming the optical waveguide on the
- 6       first substrate.
- 7    28. The method of Claim 27, wherein the walls of the detection volume are formed at
- 8       least in part from material used to form the cladding of the optical waveguide.
- 9    29. The method of Claim 27, wherein the walls of the detection volume are formed at
- 10       least in part by material used to form the core of the optical waveguide.
- 11   30. The method of Claim 29, wherein the core material forming the core of the optical
- 12       waveguide and partly forming the walls of the detection volume is non-contiguous.
- 13   31. The method of Claim 27, further comprising:  
14       forming bottom surfaces and walls on a common substrate wafer, thereby  
15       substantially defining multiple detection volumes concurrently;  
16       forming multiple corresponding optical waveguides concurrently on the common  
17       substrate wafer; and  
18       dividing the substrate wafer into individual substrates having thereon at least one  
19       detection volume and corresponding optical waveguide.
- 20   32. The method of Claim 24, further comprising:  
21       forming the optical waveguide on a waveguide substrate; and  
22       mounting the optical waveguide on the first substrate.
- 23   33. The method of Claim 32, further comprising forming a passage through one of the  
24       walls of the detection volume for admitting into the detection volume at least a  
25       portion of the light emerging from the end face of the optical waveguide.

- 1       34. The method of Claim 32, further comprising forming a substantially transparent  
2           segment of one of the walls of the detection volume for admitting into the detection  
3           volume at least a portion of the light emerging from the end face of the optical  
4           waveguide.
- 5       35. The method of Claim 32, further comprising forming a reflective coating on an area  
6           of the first substrate where light emerging from the end face of the optical  
7           waveguide may enter the detection volume.
- 8       36. The method of Claim 32, further comprising forming a reflective coating on the  
9           waveguide substrate at the end face of the optical waveguide.
- 10      37. The method of Claim 24, further comprising substantially covering the end face of  
11           the optical waveguide, substantially filling the detection volume, and substantially  
12           filling an optical path between the end face of the optical waveguide and the  
13           detection volume, with substantially transparent embedding material.
- 14      38. The method of Claim 37, further comprising forming a passage through at least  
15           one wall of the detection volume admitting liquid embedding material into the  
16           detection volume.
- 17      39. The method of Claim 24, wherein the detection volume is substantially sealed by  
18           mounting of the photodetector over the upper opening of the detection volume.
- 19      40.     The method of Claim 39, further comprising forming a substantially flat  
20           substantially contiguous upper mounting surface surrounding the upper opening of  
21           the detection volume, wherein the upper mounting surface engages the  
22           photodetector to substantially seal the detection volume.
- 23      41. The method of Claim 39, further comprising forming multiple substantially flat  
24           substantially coplanar upper mounting surfaces arranged around the upper  
25           opening of the detection volume, wherein the upper mounting surfaces engage the  
26           photodetector and gaps between the upper mounting surfaces are substantially

1       filled with at least one of adhesive and solder, thereby substantially sealing the  
2       detection volume.

3   42. The method of Claim 24, further comprising forming a reflective coating on at least  
4       a portion of the bottom surface of the detection volume.

5   43. The method of Claim 42, wherein the reflective coating comprises a metallic  
6       coating.

7   44. The method of Claim 43, wherein the metallic reflective coating serves as an  
8       electrical contact for the photodetector.

9   45. The method of Claim 24, wherein at least a portion of the inner face is tilted  
10      upward.

11   46. The method of Claim 24, further comprising adapting at least a portion of the inner  
12      face is for reducing optical feedback from the detection volume through the end  
13      face into the optical waveguide.

14   47. The method of Claim 24, wherein the end face of the optical waveguide is tilted  
15      downward so that light emerging from the end face is refracted toward the  
16      photodetector.

17   48. An optical apparatus, comprising:  
18       a bottom surface and walls formed on a first substrate and substantially defining a  
19       detection volume and an upper opening thereof;  
20       a semiconductor laser having a first laser end face and a second laser end face,  
21       the semiconductor laser aligned substantially parallel to the first substrate and  
22       positioned so that at least a portion of light emerging from the first laser end  
23       face enters the detection volume; and  
24       a photodetector having an active area on a detector substrate, the detector  
25       substrate mounted on the first substrate so as to cover at least a portion of the  
26       upper opening of the detection volume with at least a portion of the active area  
27       exposed to the detection volume.

- 1        49. The apparatus of Claim 48, further comprising an optical waveguide positioned so
- 2                that at least a portion of light emerging from the second laser end face enters the
- 3                optical waveguide.
- 4        50. The apparatus of Claim 49, wherein the optical waveguide comprises a planar
- 5                optical waveguide formed on the first substrate.
- 6        51. The apparatus of Claim 49, wherein the optical waveguide is mounted on the first
- 7                substrate.
- 8        52. The apparatus of Claim 49, wherein at least a portion of the light emerging from
- 9                the second laser end face enters the optical waveguide through an end face
- 10                thereof.
- 11      53. The apparatus of Claim 49, wherein at least a portion of the light emerging from
- 12                the second laser end face enters the optical waveguide by transverse-coupling
- 13                thereto.
- 14      54. The apparatus of Claim 48, wherein the semiconductor laser is formed on the first
- 15                substrate.
- 16      55. The apparatus of Claim 48, wherein the semiconductor laser is formed on a laser
- 17                substrate and mounted on the first substrate.